We claim:

1. An apparatus for controllably generating sparks, the apparatus comprising, in combination:

a spark generating device;

at least two output stages connected to the spark generating device, each of the output stages including: (1) an energy storage device to store energy; (2) a controlled switch for selectively discharging the energy storage device; and (3) a network for transferring the energy discharged by the energy storage device to the spark generating device;

means for charging the energy storage devices and at least partially isolating the energy storage device of each output stage from the energy storage devices of the other output stages; and,

a logic circuit connected to the controlled switches of the at least two output stages for selectively triggering the output stages to transfer their stored energy to the spark generating device to generate a spark.

2. An apparatus as defined in claim 1 wherein the logic circuit triggers the controlled switches in all of the output stages to transfer substantially all of the energy stored in the output stages to the spark generating device.

3. An apparatus as defined in claim 2 wherein the logic circuit triggers the controlled switches at substantially the same time.

4. An apparatus as defined in claim 2 wherein the logic circuit triggers at least one of the controlled switches at a different time than the other controlled switches to shape the plume of the spark generated by the spark generating device.

5. An apparatus as defined in claim 4 wherein the energy output by the output stage including the at least one of the controlled switches partially overlaps with the energy output by another output stage.

6. An apparatus as defined in claim 4 wherein the energy output by the output stage including the at least one of the controlled switches does not overlap with the energy output by the other output stages.

7. An apparatus as defined in claim 1 wherein the logic circuit triggers less than all of the controlled switches in the output stages to transfer a portion of the energy stored in the output stages to the spark generating device.

8. An apparatus as defined in claim 7 wherein the logic circuit triggers the less than all of the controlled switches at substantially the same time.

9. An apparatus as defined in claim 7 wherein the logic circuit triggers at least one of the less than all of the controlled switches at a different time than the other controlled switches to shape the plume of the spark generated by the spark generating device.

10. An apparatus as defined in claim 9 wherein the energy output by the output stage including the at least one of the controlled switches partially overlaps with the energy output by another output stage.

11. An apparatus as defined in claim 9 wherein the energy output by the output stage including the at least one of the controlled switches does not overlap with the energy output by the other output stages.

12. An apparatus as defined in claim 1 wherein the spark generating device is an igniter plug.

13. An apparatus as defined in claim 1 wherein the spark generating device is a spark plug.

14. An apparatus as defined in claim 1 the spark generating device is incorporated into a spacecraft thruster.

15. An apparatus as defined in claim 1 wherein the spark generating device is a spark rod.

16. An apparatus as defined in claim 1 wherein the energy storage device is a capacitor.

17. An apparatus as defined in claim 16 wherein the energy storage devices of the at least two output stages have different capacitances.

18. An apparatus as defined in claim 17 wherein the capacitances of the energy storage devices are binary weighted.

19. An apparatus as defined in claim 1 wherein the controlled switches of the output stages comprise solid-state switches.

20. An apparatus as defined in claim 19 wherein the solid-state switches of the output stages comprise silicon controlled rectifiers.

21. An apparatus as defined in claim 1 wherein each of the at least two output stages further includes a triggering circuit coupled to the controlled switch and to the logic circuit for triggering the controlled switch in response to a control signal from the logic circuit.

22. An apparatus as defined in claim 1 wherein at least one of the networks of the at least two output

stages comprises an inductor connected so as to pass current when the controlled switch becomes conductive such that the current passes through both the inductor and the spark generating device, and a diode to ensure nominally unidirectional current flow through the spark generating device.

23. An apparatus as defined in claim 22 further comprising a resistor in each network wherein the inductor and the resistor of each network form a low-pass filter to prevent untriggered ones of the at least two output stages from being false-triggered by the discharging of any of the other output stages.

24. An apparatus as defined in claim 1 wherein the inductor of at least one of the networks comprises one winding of a transformer, a second winding of the transformer being connected to the controlled switch of the at least one of the networks and being magnetically coupled to the first winding to induce a transient voltage in the first winding when the controlled switch is triggered.

25. An apparatus as defined in claim 1 wherein the inductor in the network of a first one of the at least two output stages comprises one winding of a transformer, and the inductor in the network of a second one of the at least two output stages comprises a second winding of the transformer, the second winding being magnetically coupled to the first winding of the transformer to induce a high voltage therein when the second one of the at least two output stages is triggered.

26. An apparatus as defined in claim 1 wherein the networks of the output stages are coupled to a common output, the common output is coupled to a first winding of a transformer, the first winding is coupled to the spark

generating device, a second winding of the transformer is connected to one of the controlled switches, and the second winding is magnetically coupled to the first winding to induce a transient voltage therein.

27. An apparatus as defined in claim 1 wherein at least one of the networks of the at least two output stages comprises an inductor connected so as to pass current to and from the spark generating device, and a diode coupled in parallel with the controlled switch to permit reverse current flow during a bipolar discharge.

28. An apparatus as defined in claim 27 further comprising a resistor in each network wherein the inductor and the resistor of each network form a low–pass filter to prevent the at least two output stages from being false–triggered by the discharging of any of the other output stages.

29. An apparatus as defined in claim 1 wherein each of the networks of the at least two output stages includes a diode to at least partially isolate each of the at least two output stages from the other output stages.

30. An apparatus as defined in claim 1 wherein the charging and isolating means comprises a charging circuit and at least two isolating diodes, each of the isolating diodes being associated with one of the at least two output stages.

31. An apparatus as defined in claim 30 wherein the charging circuit comprises at least one controlled switch for selectively connecting the output stages to a source of energy.

32. An apparatus as defined in claim 30 wherein the charging circuit comprises a flyback converter for selectively providing energy to the output stages.

33. An apparatus as defined in claim 32 wherein the flyback converter includes at least one input for switching the converter between a charge state and a stop state for controlling the charging of the energy storage devices.

34. An apparatus as defined in claim 30 wherein the charging circuit charges each of the output stages to substantially the same voltage.

35. An apparatus as defined in claim 30 wherein the charging circuit charges at least one of the output stages to a different voltage than the other output stages.

36. An apparatus as defined in claim 30 wherein the charging circuit disconnects the output stages from the energy source at least while the energy storage devices are discharging.

37. An apparatus as defined in claim 36 wherein the controlled switches of the output stages comprise silicon controlled rectifiers and wherein the disconnection of the energy source permits the silicon controlled rectifiers to transition to their non—conducting states.

38. An apparatus as defined in claim 1 wherein the charging and isolating means comprises a charging circuit having an output transformer with multiple secondary windings, each secondary winding being associated with at least one of the output stages.

39. An apparatus as defined in claim 1 wherein the charging and isolating means comprises at least two charging circuits, each of the charging circuits being associated with one of the at least two stages for charging the energy storage devices independently of one another.

40. An apparatus as defined in claim 39 wherein at least one of the charging circuits charges its associated output stage to a voltage different from at least one of the other output stages.

41. An apparatus as defined in claim 40 wherein the logic circuit triggers the output stage associated with the at least one of the charging circuits earlier in time than at least one other output stage to deliver an initial pulse to the spark generating device.

42. An apparatus as defined in claim 1 further comprising a feedback circuit connected between at least one of the output stages and the charging and isolating means for controlling the charging of the energy storage devices in the output stages.

43. An apparatus as defined in claim 42 wherein the feedback circuit comprises a voltage sensing network for measuring the voltage across the energy storage device in the at least one of the output stages and a comparator for comparing the measured voltage to a reference voltage, the charging and isolation means terminating the charging of the output stages when the comparator indicates that the measured voltage and the reference voltage coincide.

44. An apparatus as defined in claim 43 wherein the comparator provides the logic circuit with a fire signal when the measured voltage and the reference voltage coincide and the logic circuit selectively triggers the

controlled switches in response to the fire signal to create a spark.

45. An apparatus as defined in claim 1 wherein the logic circuit comprises a timer for delaying the discharge of at least one of the output stages relative to the other output stages.

46. An apparatus as defined in claim 1 wherein the logic circuit comprises a trigger logic circuit and an energy/delay matrix, the energy/delay matrix containing information indicating which of the output stages are to be fired.

47. An apparatus as defined in claim 1 wherein the logic circuit comprises a trigger logic circuit and an energy/delay matrix, the energy/delay matrix containing information indicating that at least one of the output stages should be triggered later in time than the other output stages.

48. An apparatus as defined in claim 1 wherein the logic circuit comprises a microprocessor for controlling the triggering of the at least two output stages.

49. An apparatus as defined in claim 48 wherein the logic circuit further comprises a memory associated with the microprocessor for storing data indicating which of the at least two output stages are to be fired.

50. An apparatus as defined in claim 48 wherein the logic circuit further comprises a memory associated with the microprocessor for storing data indicating that at least one of the output stages should be triggered later in time than the other output stages.

51. An apparatus as defined in claim 1 wherein the networks are coupled to a common output connected to the spark generating device, and a feedback circuit is coupled to the logic circuit and to the common output to enable the logic circuit to monitor the energy being transferred to the spark generating device.

52. An apparatus as defined in claim 1 further comprising at least a second spark generating device and steering circuitry coupled to the networks of the at least two output stages to selectively direct the stored energy transferred by the output stages to one of the spark generating devices.

53. An apparatus as defined in claim 52 wherein the steering circuitry directs the stored energy to each of the spark generating devices sequentially.

54. An apparatus as defined in claim 1 wherein the spark generating device is associated with an engine, the engine including sensors coupled to the logic circuit for providing feedback signals to the logic circuit indicative of at least one operating condition of the engine.

55. An apparatus for controllably generating sparks comprising:

a spark generating device for generating sparks in response to an energy pulse received at an input;

a first capacitor to store and selectively discharge energy;

a first controlled switch connected to the first capacitor to selectively discharge the energy stored in the first capacitor to the input of the spark generating device in response to a first control signal;

a second capacitor to store and selectively discharge energy;

a second controlled switch connected to the second capacitor to selectively discharge the energy stored in the second capacitor to the input of the spark generating device in response to a second control signal;

means for charging the first and second capacitors and for at least partially isolating the first capacitor from the second capacitor such that either of the first and second capacitors can be discharged without discharging the other; and,

a logic circuit for providing the first and second control signals to the first and second controlled switches, respectively, to selectively discharge the first and second capacitors to the input of the spark generating device.

56. An apparatus as defined in claim 55 wherein the first and second capacitors have different capacitances.

57. An apparatus as defined in claim 55 wherein the first and second controlled switches are solid–state devices.

58. An apparatus as defined in claim 55 wherein the charging and isolating means comprises a first diode associated with the first capacitor, a second diode associated with the second capacitor, and a charging circuit for selectively charging the first and second capacitors to an energy source via the first and second diodes.

59. An apparatus as defined in claim 58 wherein the charging circuit comprises at least one converter.

60. An apparatus as defined in claim 55 wherein the charging and isolating means comprises first and second converters, the first and second converters being

associated with the first and second capacitors, respectively, the first converter being configured to charge and allow discharging of the first capacitor independently of the second capacitor and the second converter being configured to charge and allow discharging of the second capacitor independently of the first capacitor.

61. An apparatus as defined in claim 55 wherein the logic circuit comprises a timer for discharging one of the first and second capacitors later in time than the other.

62. An apparatus as defined in claim 55 wherein the logic circuit comprises a microprocessor.

63. An apparatus for controllably generating sparks comprising, in combination:

a spark generating device;

a first converter;

a first output stage connected to the first converter and to the spark generating device, the first output stage including: (1) an energy storage device to store the energy received from the first converter; (2) a controlled switch for selectively discharging the energy storage device; and (3) a network for transferring the energy discharged by the energy storage device to the spark generating device;

a second converter;

a second output stage connected to the second converter and to the spark generating device, the second output stage including: (1) an energy storage device to store the energy received from the first converter; (2) a controlled switch for selectively discharging the energy storage device; and (3) a network for transferring the energy discharged by the energy storage device to the spark generating device; and

a logic circuit connected to the controlled switches of the first and second output stages for selectively triggering the output stages to transfer their stored energy to the spark generating device to generate a spark.

64. A method for controllably generating sparks at a spark generating device, the method comprising the steps of:

charging a first energy storage device to a first predetermined voltage;

charging a second energy storage device which is at least partially isolated from the first energy storage device to a second predetermined voltage;

triggering a first controlled switch associated with the first energy storage device at a first time to discharge the first energy storage device to the spark generating device in the form of an energy pulse; and,

triggering a second controlled switch associated with the second energy storage device at a second time to discharge the second energy storage device to the spark generating device in the form of an energy pulse.

65. A method as defined in claim 64 wherein the first predetermined voltage and the second predetermined voltage are substantially equal.

66. A method as defined in claim 64 wherein the first predetermined voltage and the second predetermined voltage are different.

67. A method as defined in claim 64 wherein the first energy storage device has a first capacitance and the second energy storage device has a second capacitance, the first capacitance being substantially equal to the second capacitance.

68. A method as defined in claim 64 wherein the first energy storage device has a first capacitance and the second energy storage device has a second capacitance, the first capacitance being different from the second capacitance.

69. A method as defined in claim 64 wherein the first time and the second time are substantially the same.

70. A method as defined in claim 64 wherein the energy pulse discharged by the first energy storage device overlaps with the energy pulse discharged by the second energy storage device.

71. A method as defined in claim 64 wherein the first time occurs later than the second time.

72. A method as defined in claim 71 wherein the energy pulse discharged by the first energy storage device partially overlaps with the energy pulse discharged by the second energy storage device.

73. A method as defined in claim 71 wherein the energy pulse discharged by the first energy storage device does not overlap with the energy pulse discharged by the second energy storage device.